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COMBUSTION BYPRODUCTS RECYCLING CONSORTIUM

Ashlines

a program of the National Mine Land Reclamation Center at West Virginia University, in cooperation with the U.S. Department of Energy-National Energy Technology Laboratory
www.netl.doe.gov

To promote and support the commercially viable and environmentally sound recycling of coal combustion byproducts for productive uses, through scientific research, development, and field testing

CBRC History & Status: Eight Years of Identifying Markets for Millions of Tons of Waste

Once viewed as a useless, dirty, unsightly, and copious liability, coal combustion byproducts (CCBs) are now regarded as a largely untapped, recyclable resource with tremendous industrial market potential. In recent years, CCBs have been used successfully as a structural fill for an airport runway extension, as a safe backfill for an abandoned mine pit, and as a treatment for acid mine drainage. Other promising CCB demonstration projects are using fly ash to replace foundry sand and flue gas desulfurization (FGD) scrubber sludge to manufacture countertops, tiles, and other materials for the construction industry. High-carbon CCBs and FGD byproducts have been used to fabricate a permeable roadway base material, FGD soil supplements are boosting soybean and alfalfa crop yields, and FGD sludge briquettes are helping to control beach erosion. And that's just a sample.

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CBRC-supported investigators at Energy Industries of Ohio Casting Development Center are investigating the feasibility of using CCBs as a substitute for foundry sands, thus replacing a portion or all of the virgin silica sand used for foundry mounds and cores. The materials will be tested in a "live fire" production environment at General Motors Corporation's Powertrain Casting Plant in Defiance, Ohio. Actual molds and/or cores will be made from both currently available ashes and ashes that contain higher carbon content, expected to result from new environmental requirements. The photo above is of a compression test at the point of failure. (02-CBRC-E10)

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Fact 1: Each year, the U.S. electric utility industry generates about 100 million tons of coal combustion byproducts. Just over half of this amount is fly ash, approximately one-fourth is sludge from wet flue gas scrubbers, another 16 percent is boiler ash (a heavier, coarser solid removed from the bottom of a boiler), and about 7 percent is boiler slag (a hard, glassy material made from boiler ash that has been melted by the heat of the combustor). Currently, only about a third of this coal ash and just over one fourth of the scrubber waste is recycled in commercially beneficial uses. The largest amount is fly ash that is typically used as a Portland cement replacement in concrete and concrete products. The remainder, more than 70 million tons a year, is disposed of in impoundments and landfills.[1]

Fact 2: The U.S. relies on oil and natural gas from the Middle East, a market that has become increasingly unstable, expensive, and volatile. If we had to rely exclusively on domestic supplies of fossil fuels to meet our energy demands, according to calculations based on Energy Information Administration (EIA) data, at current reserve and production rates, the U.S. has approximately 9.5 years proven reserves of natural gas, 12.2 years proven reserves of oil, and 247 years proven reserves of coal.[2]

Observation: That figure of 100 million tons of CCBs being produced annually in the U.S. may, in the near future, get *much* bigger. And, strict limits on NOx emissions, mandated by the 1990 Clean Air Act have resulted in utility burner/boiler modifications that frequently yield higher carbon concentrations in fly ash, which restricts its use as a concrete ingredient—historically ash's biggest commercial market. If newer, "clean coal" combustion and gasification technologies are adopted, their byproducts may add to the CCB management challenge. The time is ripe for innovation, research, and investment in the recycling and industrial application of CCBs.

Brief History of CCB Utilization and the CBRC

Dam construction was the first large market for using fly ash as a substitute for Portland cement. One of the first large-volume uses of fly ash was in the construction of the Hungry Horse Dam in Montana in 1949. Not until 1958, though, did a group of researchers start working on problems related to the under-utilization of coal ash. The National Ash Association (NAA) was formed 9 years later, shortly after the first Ash Utilization Symposium in 1967. In 1985, the American Coal Ash Association (ACAA) succeeded the NAA, choosing a perfect symbol—the phoenix—for its logo.[3]

In 1992, *Use of Coal Combustion By-Products: Status and Opportunities in Region 8*, a report by Bryggman and Nillick prepared for the U.S. Department of Energy, identified typical markets for CCBs in DOE's Region 8 (Colorado, Montana, North and South Dakota, Utah, and Wyoming). Positive response to that report led to the formation of the Western Region Ash Group (WRAG) in 1994.[4]

In the eastern U.S., West Virginia is a major coal producer and has played a prominent role in coal-related research. It was a natural choice, then, that in 1998, with support from the U.S. Department of Energy's National Energy Technology Laboratory (DOE-NETL) in Morgantown, West Virginia, the Combustion Byproducts Recycling Consortium (CBRC) was established in Morgantown also, at West Virginia University (WVU). The CBRC is headquartered at the West Virginia Water Research Institute (WVWRI), located at WVU's National Research Center for Coal & Energy (NRCCE). The Consortium's director, Dr. Paul Ziemkiewicz has worked with CCBs since the early 1980s and been a member of the WVU research community and director of the WVWRI for 18 years.

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The CBRC Today

The mission of the CBRC is to identify beneficial uses for those approximately 100 million tons of coal combustion byproducts that are generated every year. The Consortium supports innovative ideas, and its projects—performed by universities and businesses research teams—are demonstrating that CCBs have many high-volume applications.

The CBRC continues to be funded and overseen by DOE NETL and is supported by the ACAA, the Interstate Mining Compact Commission, and numerous state and corporate sponsors. To meet its goals, the CBRC provides seed money to researchers to develop innovative applications for CCBs, while testing the economic and environmental viability of these applications.

No byproduct recycling technology, however, is likely to be adopted by industry unless it is more cost-effective than disposal. Therefore, the utility industry—as producer and owner of CCBs—provides guidance to the CBRC R&D program, as well as government agencies and private-sector organizations that may have use for CCBs. The CBRC synthesizes information from these organizations and uses it to develop a balanced R&D program that addresses the needs of both producers and end-users of CCBs.

CBRC's Structure: National Steering Committee and Regional Centers

The CBRC's National Steering Committee (NSC) is its key decision-maker. Among its many functions, the NSC sets priorities based on regional recommendations, evaluates proposals, and recommends proposals to DOE-NETL for funding consideration. The types of coals burned by electric utilities and the technologies employed for emission control greatly affect the characteristics of the byproducts that are produced. Recognizing that these characteristics often vary from region to region and that regional prioritization of research needs is determined by transportation costs and state regulations governing CCB disposal and utilization, the NSC works with regional advisors and reviewers from the Eastern, Midwestern, and Western regions of the U.S., with each region developing its own research priorities.

Each region develops its own specific research priorities based on its own particular needs, with all three regions supporting projects with a market potential for high-volume beneficial utilization of CCBs and investigations into the impacts of changing air quality standards on the composition and quality of fly ash and FGD byproducts. Environmental impacts, technology development, and long-term economic benefits for producers and end-users are integral to every undertaking.

> *"if we're going to add to the utilization rate, we also need to identify new markets, and that means finding applications that make the most of the unique properties of CCBs, applications for which there are few competing materials in the marketplace right now."*

Progress to Date

Between 1998 and 2005, the CBRC funded 42 projects, totally over $8 million (nearly $4.1 million in federal funds, and more than $4.4 million in cost share.) Many of the technologies developed through CBRC research have been selected for large-scale demonstrations, and several technologies have been adopted by the government as agency policy or by industry as commercial processes. The following list provides a sampling of CBRC-supported research, by region.

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CBRC Regional Research

Northeast Region

- In Preston County, West Virginia, a demonstration project has reclaimed 35 acres of land degraded by strip mining by amending the site's soil using fly ash and planting five species of hardwood trees. Ultimately, the project is testing whether it is economically advantageous for industry and landowners to recycle CCBs and restore abandoned mine lands, thus converting a degraded habitat into an environmental commodity. (99-EC-E17)
- At Rostaver Airport near Pittsburgh, Pennsylvania, CBCs from a nearby power plant were used as structural fill to expand the airport's runway. The favorable engineering properties of the low-permeability cementitious (LPC) CCB material produced at the Elrama power station made it uniquely qualified to meet the Westmoreland County Airport Authority's objective. This project is one of the largest projects of its type using coal combustion byproducts and serves as an excellent example of an environmentally friendly solution to CCB management. (00-CBRC-E41)
- In another project funded by the CBRC, Energy Industries of Ohio recently demonstrated the suitability of fly ash as a replacement for traditional foundry sands, which have certain negative qualities including cost; varying dust contents; health risks; and excavation, cleaning, and segregating requirements. (02-CBRC-E10 and 00-CBRC-E42)
- Also in Ohio, one of the first CBRC-funded research teams demonstrated that FGD byproducts provide sulfur and trace mineral nutrition for alfalfa and soybean crops. (99-EC-E08)
- Because excessive ammonia, or even the presence of an ammonia odor, can severely affect the ability to utilize and sell fly ash for any purpose, CBRC researchers in Pennsylvania and Kentucky characterized and compared the ammonia content of fly ash from different power plants that operate SCR (selective catalytic reduction) and SNCR (selective noncatalytic reduction) systems for controlling NOx emissions. Their project in-

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cluded investigations of ammonia release, including leaching and thermal studies; an evaluation of the potential impacts on plant equipment, air quality, and water quality (surface and ground); ash disposal operations; and ash marketing. (99-EC-E06)

- In Homestead, Florida, CBRC researchers mixed Class F fly ash with yard waste and biosolids to grow tomatoes, thus determining the beneficial effects of CCBs on the physical and chemical properties of typical nutrient-poor Florida soils and the growth of Florida-grown vegetables. (99-EC-E11).
- CBRC researchers at Louisiana State University have proven the feasibility of using light-weight stabilized FGD sludge briquettes as a fill material to control beach erosion (00-CBRC-M11)

Midwest Region

- In Illinois, researchers at Southern Illinois University at Carbondale (SIUC) have designed utility poles made from CCBs. They estimate that currently 250,000 wooden poles with an average height of from 30–40 feet and another 1 million poles averaging 15–30 feet high are used annually in the Midwest alone. To replace 250,000 wooden poles with CCB-fabricated poles would save that many trees and utilize from 77,500 to 100,000 tons of CCBs at a rate of 400–600 pounds of CCBs per pole. (99-EC-M07)
- Also at SIUC, CBRC researchers have studied fly ash boron concentrations (99-ECM-04) and fabricated countertops, tiles, and other structural materials from FGD scrubber sludge. (99-EC-M01)
- In Wisconsin, CBRC researchers have fabricated four concrete mixtures using high-carbon CCBs and FGD byproducts, which can be used in permeable roadway base construction. (99-EC-M06)

Western Region

- The Varra Coal Ash Project is an ongoing study to determine the feasibility of using coal ash to reclaim flooded gravel mine quarries in Weld County, Colorado. The use of coal ash as fill in saturated environments has been discouraged by most regulatory agencies; it took 4 years to obtain required permits to conduct this study to assess potential impacts of large-scale coal ash reclamation on groundwater resources. Analytical data generated from the Varra project indicate that the leaching characteristics of the coal ash used in the study

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The introduction of fly ash and bottom ash into the foundry industry could create a new use for CCBs and perhaps solve some the the problems associated with the use of natural sand, the traditional base material of foundry molding and core mixtures. This photo is of a pour test using iron at General Motors Corporation's Powertrain Casting Plant in Defiance, Ohio, where fly ash from First Energy is being used in place of silica sand. (02-CBRC-E10)

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Researchers athe Southern Illinois University of Illinois at Carbondale have developed technology for converting sulfate-rich FGC scrubber slude into decorative building materials like the sample countertop tiles shown at left. (00-CBRC-M11)

are relatively benign and that large-scale ash reclamation may be feasible at this location and meet drinking water standards. (00-CBRC-W02)

- Specific fly ashes from Colorado bituminous and Wyoming subbituminous coals have been proven to capture from 75% to 98% of mercury. A study conducted in Pueblo, Colorado investigated the feasibility of employing these fly ash materials as mercury sorbents on a slipstream from a full-scale generating unit. An economic analysis showed that for the flue gas conditions and plant configuration of the host site, this use of fly ash-derived sorbents would be cost-competitive with the injection of activated carbon. This application of fly ash-derived sorbents for mercury control is anticipated to allow the continued sale of this CCB. (00-CBRC-W4)

The CBRC Vision for the Future

By 2010, the CBRC hopes to

- increase the overall ash utilization rate from 34% to 50%,
- increase the current rate of flue gas desulfurization byproduct use,
- continue to examine the environmental impact of CCB use and disposal, and
- increase the number of uses for CCBs considered allowable under state regulations.

According to William Aljoe, the US DOE NETL's contracting officer representative to the CBRC, "The three biggest markets for CCBs are (1) cement and concrete, (2) structural fill, and (3) mine reclamation, and these represent the biggest opportunity for the CBRC to reach its goal of increasing overall utilization of CCBs to 50% by 2010."

"And," adds Paul Ziemkiewicz, CBRC Director, "if we're going to add to the utilization rate, we also need to identify new markets, and that means finding applications that make the most of the unique properties of CCBs, applications for which there are few competing materials in the marketplace right now."

Bearing these goals for 2010 in mind, the National Steering Committee met in February 2006 to select projects for its current funding cycle. Of the 19 full proposals submitted, 10 were selected for funding, with projects ranging from 1-3 years in duration, and project total values ranging from approximately $24,987 to $222,682. The CBRC awarded approximately $1.5 million, with a commitment of over $¾ million in total cost share.

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CBRC 2006 Project Awards

The NSC chose five concrete-related projects, two agricultural projects, one in situ treatment of acid mine drainage, one project on brick manufacturing, and one project on CCB marketing strategies. The following are the 10 projects the NSC chose to recommend to DOE-NETL for funding. Awards will be made in yearly increments based upon performance and DOE funding availability:

- **05-CBRC-M09**, "Cold In-Place Recycling of Asphalt Pavements Using Self Cementing Fly Ash"; principal investigator: Anil Misra, University of Missouri. A demonstration of this fly ash pavement use was conducted in August 2004 on approximately 2.5 miles of low-traffic roadway. This project will build upon those results and establish the parameters for engineering design of rehabilitated road pavements with a fly ash-stabilized recycled asphalt base layer. CBRC award: $24,987.
- **05-CBRC-W8**, "Evaluation of the Durability and Commercial Potential of 100 Percent Fly Ash Concrete"; principal investigator: Jerry Stephens, Montana State University. Portland cement is the binder material in traditional concretes for construction applications, but although it is an excellent performer, Portland cement production is an energy-intensive process. The objective of this project is to determine the long-term durability and possible economic benefits of using 100 percent fly ash concrete in construction applications. Due to recent domestic shortages of Portland cement, as well as cost increases, concrete producers are motivated to explore fly ash binders. CBRC award: $95,900.
- **05-CBRC-M16**, "In Situ Stabilization of Gravel Roads with CCBs"; principal investigator: Tuncer B. Edil, University of Wisconsin-Madison. This project will test the feasibility of using low-cost, rapid-application, self-cementing CCPs to stabilize deteriorating gravel roads, of which, the investigators estimate there to be 1.6 million miles or 53% of all roads in the U.S. CBRC award: $130,362.
- **05-CBRC-W04**, "Using Class C Fly Ash to Mitigate Alkali-Silica Reactions in Concrete"; principal investigator: Bruce Dockter, University of North Dakota Energy & Environmental Research Center. This multiyear investigation will evaluate the performance of several Class C fly ashes (>10% CaO) as a means to mitigate alkali-silica reactions (ASR) in concrete. CBRC award: $150,000.
- **05-CBRC-M20**, "New Technology-Based Approach to Advance Higher Volume Fly Ash Concrete with Acceptable Performance"; principal investigator: Karthik Obla, National Ready Mixed Concrete Association. Surveys indicate that the average fly ash content in all ready-mixed concrete is only about 10%. This project suggest novel science-based approaches to address this low percentage by upping high fly ash concentrations during warm weather applications when optimal strength gain and setting time can be achieved. CBRC award: $199,680.
- **05-CBRC-M23**, "Manufacturing Building Products with Fly Ash and Advanced Coal Combustion"; principal investigator: Mei-In Melissa Chou, Illinois State Geological Survey (ISGS). For the past several years, researchers at the ISGS have been working with the brick industry to develop high-quality, marketable, fired bricks that use high volumes of Class F fly ash as a raw material. The purpose of this project is to demonstrate the use of CCBs in the production of high-quality fired bricks and innovative autoclaved aerated concrete (AAC) blocks. CBRC award: $51,000.

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- **05-CBRC-E08**, "Field Testing of Arsenic and Mercury Bioavailability Model from Land-Applied CCBs"; principal investigator: Paul A. Pier, Tennessee Valley Authority. This project will investigate the environmental effects of CCB use, including the potential bioavailability of contaminants to soil organisms, plants, and possibly animals and humans. CBRC award: $46,000.
- **05-CBRC-M22**, "Community-based Social Marketing: The Tool to Get Target Audiences to Use CCBs"; principal investigator: Richard Buggeln, University of Tennessee Center for Industrial Services. The overarching goal of this project is to demonstrate the utility of community-based social marketing (CBSM) as a method for implementing sustainable agricultural uses of FGD-gypsum by farmers, and in so doing, develop a model that can be expanded and applied to other CCB markets. CBSM is based on motivations for human behavior and is an alternative to traditional information-based campaigns. CBRC award: $200,193.
- **05-CBRTC-W03**, "Evaluation of CCBs for In Situ Treatment of Acid Mine Drainage"; principal investigator: Geoffrey A. Canty, CC Environmental, LLC. This project will follow-up the investigation of a 1994 alkaline injection technology (AIT) project in an abandoned coal mine in eastern Oklahoma, which has been under study for 11 years. This monitoring is necessary to fully evaluate the treatment effectiveness. CBRC award: $26,940.
- **05-CBRC-M22**, "National Network of Research and Demonstration Sites for Agricultural and Other Land Application Uses of FGC Products"; principal investigator: Warren Dick, The Ohio State University. With many electric utilities in the process of bringing new scrubbers on line, the amount of FGD products to be generated in the future in the U.S. will be greatly increased. This project proposes to establish a national network of sites for research/demonstration of beneficial agricultural and other land application uses of FGD products. CBRC Award: $222,682.

More Information

The CBRC's website at http://wvwri.nrcce.wvu.edu/programs/cbrc features program news, factsheets, project reports, contact information, a calendar of events, and publications, including the *Ashlines*, which is available in electronic format only (Adobe Acrobat). To be placed on the CBRC electronic mailing list, send an email to cbrc@nrcce.wvu.edu. For more information about the Combustion Byproducts Recycling Consortium and to view RFPs and project reports for any of the projects mentioned in this article, visit the Consortium's website, or contact the CBRC Consortium Manager, Tamara Vandivort, at Tamara.Vandivort@mail.wvu.edu or at 304.293.2867.

Notes

1. U.S. Department of Energy, Fossil Energy, Coal Byproducts Research, January 18, 2006. http://www.fossil.energy.gov/programs/powersystems/pollutioncontrolsoverview_coalbyproducts.html.
2. Bayless, Charles, "Energy for West Virginia," presented at the Ninth Annual Industries of the Future-West Virginia (IOF) Symposium, November 8, 2005, Charleston, WV. Proceedings to be published in Spring 2006. Mr. Bayless calculated the estimated remaining years of proven reserves by dividing current proven reserves by current production rates, based on data from the U.S. Department of Energy, Energy Information Administration (EIA). A Power Point presentation of "Energy for West Virginia" is available online at http://iofwv.nrcce.wvu.edu/.
3. Manz, Oscar and Debra Pflughoeft-Hassett, "Historical Perspective of Coal Ash Marketing and Promotion in the USA," paper presented at the World of Coal Ash Conference, April 11-15, 2005, Lexington, Kentucky.
4. "WRAG Partnership Benefits the CCB Industry," *Ashlines*, Vol. 1, No. 4 (Winter 2000). More information about the Western Region Ash Group (WRAG) can be found on the WRAG Web site at www.WRASHG.org.

Calendar

Sept. 25–28, 2006

23rd Annual International Pittsburgh Coal Conference
Pittsburgh, PA
www.engr.pitt.edu/pcc

The Twenty-Third Annual International Pittsburgh Coal Conference will focus on environmental emissions issues and technologies surrounding the continued use of coal and the development of future coal-based energy plants to achieve near-zero emissions of pollutants, reduced costs, and high thermal efficiency while producing a suite of products to meet future energy market requirements. Technical, business, and policy-related papers will be presented at the conference.

October 24-25, 2006

20th Western Fuels Symposium
International Conference on Lignite, Brown, and Subbituminous Coals
Denver, Colorado
http://www.undeerc.org/wfs/

The goal of the Twentieth Symposium on Western Fuels is to provide a forum in which industry, government, and research organizations can share up-to-date information on the role of lignite, brown, and subbituminous coals in meeting future energy demands. Low-rank fuels have unique properties that present challenges and opportunities related to meeting future environmental regulations and in the development and application of advanced technologies.

June 11–13, 2007

Sustainable Construction Materials and Technologies
Coventry University, Coventry, UK
www.uwm.edu/dept/cbu/coventry.html

This conference will highlight case studies and applied research that show new and innovative ways of achieving sustainability of construction materials and technologies. Papers have been invited on all the different materials used in construction, including cementitious materials (fly ash, wood ash, silica fume, slag, natural pozzolans, and others); aggregates; admixtures, concrete; timber; masonry; metals; plastics; glass; bitumen; lime; and gypsum, and on paints, adhesives, preservatives, and preservation processes.

Sponsored by Coventry University and University of Wisconsin-Madison Center for By-Products Utilization

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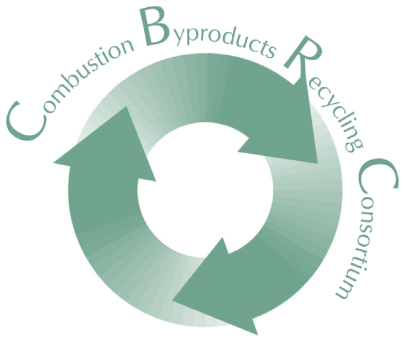

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